Another High Dispersion - Low β Recycler Insert

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Abstract

A Recycler high-η, low-β insert is created with strong bending magnets. Opposite polarity bends are separated by 180^o of phase advance, which results in coherent addition of the dispersion & a much larger value of η^* than would be anticipated from purely geometric considerations. The module fits comfortably within the RR:30 enclosure & at the midpoint $\eta/\sqrt{\beta}$ =3.75 $m^{1/2}$.

To implement Palmer cooling of pbars in the Recycler two attempts have been made to create a large $\eta/\sqrt{\beta}$ insert, neither of which was hugely successful. Norm Gelfand tried using strong bending magnets to create large dispersion in the RR:30 straight section[1]. While $\eta/\sqrt{\beta} \approx 3\ m^{1/2}$ was achieved, the insert could not fit in the tunnel. John Johnstone grew a dispersion wave in the arc cells through deliberate optical mismatches[2]. An enhancement of $\eta/\sqrt{\beta}$ from 0.275 $m^{1/2}$ to 1.250 $m^{1/2}$ was obtained but required both extensive magnet movements and additional quadrupoles across 11 arc cells.

This note records another attempt to create a high dispersion-low β insert using strong bending magnets. In the official RR:30 straight section the beam center-line is offset by 27" from the tunnel wall. In the modified lattice presented here a 10' dipole bends this trajectory 10^o away from the wall. Downstream, a dipole of opposite bend returns the beam to its original heading but offset now by 27" from the opposite wall, resulting in a total transverse displacement of only 66". The mirror-image dipole configuration further downstream restores the beam to its original closed orbit. At the insert midpoint $\beta^*_{x,y}$ = 2.00 m & η^*= –5.30 m, giving $\eta/\sqrt{\beta} = -3.75\ m^{1/2}$.

The present model differs fundamentally from Norm's earlier study in that the phase advance between opposing dipoles is fixed at 180^o by separating them with additional low β inserts. This results in the dispersion from these sources adding coherently. The overall layout of the insert is illustrated in Fig.1 and the development of the normalized dispersion phase space in Fig. 2.

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1 Norman M. Gelfand, "A Low-β, High Dispersion Insert for the Recycler Ring", MI-0175, 1996.

2 John A. Johnstone, "Dispersion-Wave Generation of a High $\eta/\sqrt{\beta}$ Insert in the Recycler", MI-0236, 1998.

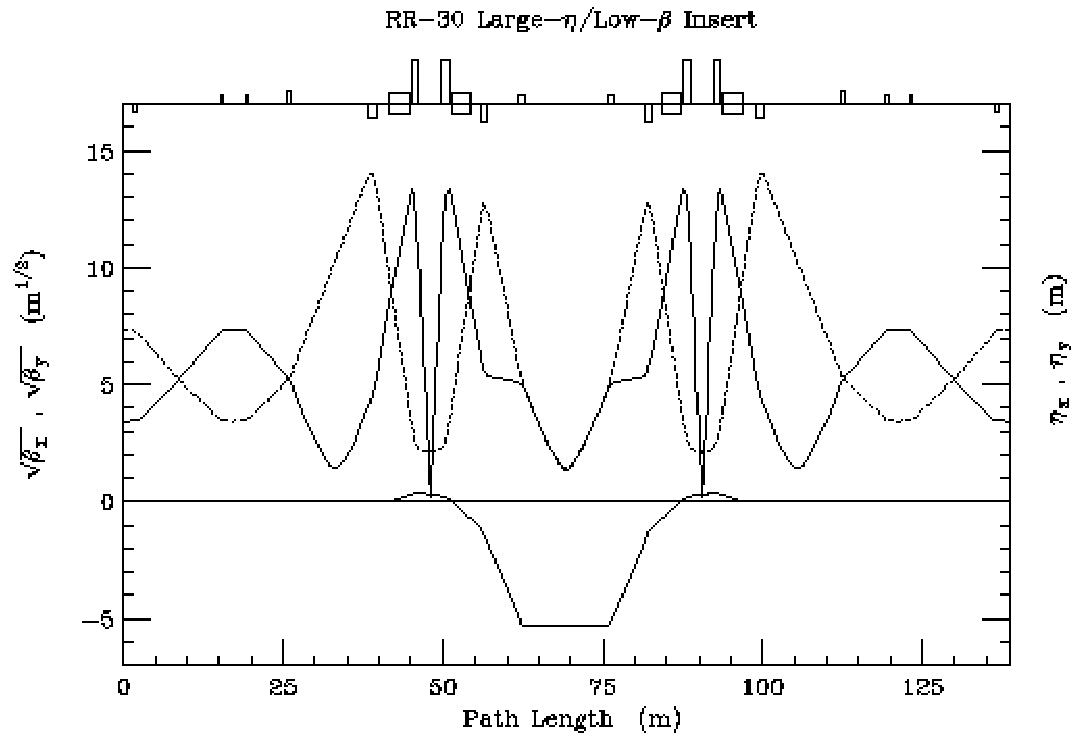

Fig. 1. Layout of the high $\eta/\sqrt{\beta}$ insert in the RR:30 straight section. At the center $\beta^*_{x,y} = 2.00$ m & $\eta* = -5.30$ m. Maximum amplitudes are in the vicinity of the dipoles: $\beta_X(\max) = 178$ m [Q3 & Q4] and $\beta_y(\max) = 196$ m [Q5].

The regular Recycler FODO structure is extended by a half-cell into the RR:30 straight section. Six powered quads match the FODO lattice optics to the low β midpoint. The primary role of quadrupoles Q3 & Q4 is to maintain 180^o of phase between the oppositely-bending dipoles. They otherwise have little impact on the optics and, consequently, the insert is inflexible to tuning.

The additional low β inserts significantly alter the tune & chromaticity from the RR:30 high β – zero-dispersion design lattice: $[\Delta\mu_X, \Delta\mu_y] = [2.347, 0.273]$, and $[\Delta\nu_X, \Delta\nu_y] = [-25.61, -3.73]$. The fractional tune changes are within the compensation range of the RR phase trombone, but the huge chromatic change would require additional sextupoles for local correction.

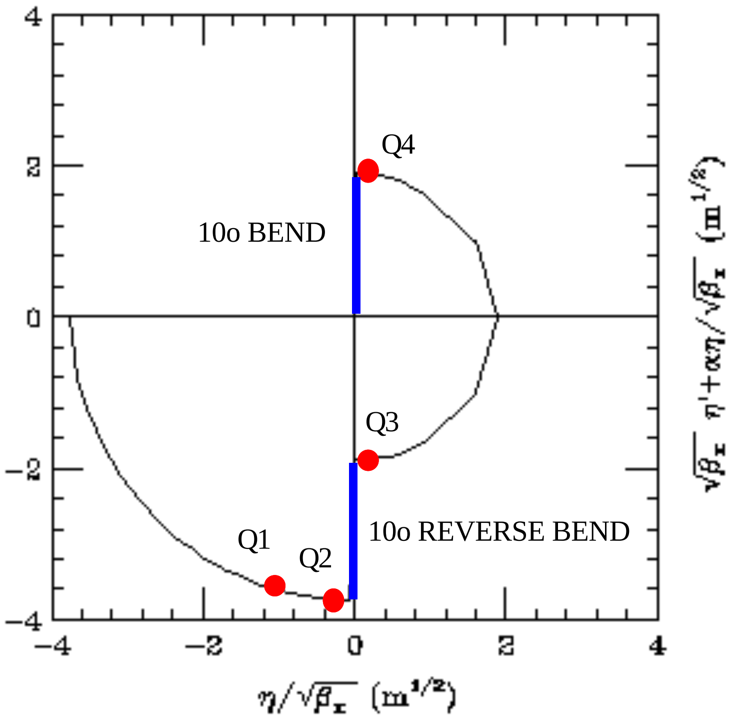

Fig. 2. Evolution of the normalized dispersion as it progresses from the first bend, through 180° where it is augmented by the reverse bend, and finally through 90° to the low β point.

Powered magnet parameters are listed in the following tables. The dipoles & quadrupoles listed are consistent with Pbar SDB & SQx-series magnets, respectively. In reality though, because the Recycler beam is situated just 12" beneath the ceiling, the 14½" half-height of these magnets would prevent them fitting in the tunnel without the further addition of a vertical dogleg. Such a solution is possible, consistent with confining vertical dispersion locally to the insert, but construction of new magnets is a more appealing option.

Sector Bend (SDB) Magnets ($B_o\,\rho$ = 29.650 T·m)			
Dipole	Length (m)	BL/Bo ρ (mr)	B (T)
B1	3.048	174.533	1.6978
B2	3.048	-174.533	1.6978

Low β - Large η Quad (SQx) Parameters ($B_o\, \rho$ = 29.650 T·m)			
Quad	Length (m)	B'/Bo ρ (m^{-2})	B ' (T / m)
Q1	1.2192	0.107803	3.1964
Q2	1.2192	0.208713	6.1884
Q3	1.2192	0.472886	14.0211
Q4	1.2192	0.472886	14.0211
Q5	1.2192	0.149090	4.4205
Q6	0.4572	0.161530	4.7894

RR30 Half-Straight Section